Single-Center Study Investigating Foreign Language Acquisition at School in Children, Adolescents, and Young Adults With Uni- or Bilateral Cochlear Implants in the Swiss German Population

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Abstract: Objective: To evaluate foreign language acquisition at school in cochlear implant patients. Study design: Cohort study. Setting: CI center. Patients: Forty three cochlear implants (CI) patients (10-18 yr) were evaluated. CI nonusers and patients with CI-explantation, incomplete datasets, mental retardation, or concomitant medical disorders were excluded. Intervention(s): Additional data (type of schooling, foreign language learning, and bilingualism) were obtained with questionnaires. German-speaking children with foreign tuition language (English and/or French) at school were enrolled for further testing. Main outcome measure(s): General patient data, auditory data, and foreign language data from both questionnaires and tests were collected and analyzed. Results: Thirty seven out of 43 questionnaires (86%) were completed. Sixteen (43%) were in mainstream education. Twenty-seven CI users (73%) have foreign language learning at school. Fifteen of these were in mainstream education (55%), others in special schooling. From 10 CI users without foreign language learning, one CI user was in mainstream education (10%) and nine patients (90%) were in special schooling. Eleven German-speaking CI users were further tested in English and six additionally in French. For reading skills, the school objectives for English were reached in 7 of 11 pupils (64%) and for French in 3 of 6 pupils (50%). For listening skills, 3 of 11 pupils (27%) reached the school norm in English and none in French. Conclusions: Almost 75% of our CI users learn foreign language(s) at school. A small majority of the tested CI users reached the current school norm for in English and French in reading skills, whereas for hearing skills most of them were not able to reach the norm.

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Conclusions: Almost 75% of our CI users learn foreign language(s) at school. A small majority of the tested CI users reached the current school norm for in English and French in reading skills, whereas for hearing skills most of them were not able to reach the norm. **Key Words:** Cochlear implants—Deaf education—Foreign language—Mainstream schooling.

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Speech development in young deaf children has already received considerable attention (1–4). Early identification of hearing loss and rehabilitation using cochlear implants (CI) allow bilaterally deaf children to attain appropriate language acquisition, even in patients from bilingual families (2). Many deaf children with CI may even enter normal schooling (5–8). In Switzerland which has four official national languages, the Swiss Conference of Cantonal Ministers of Education issued in 2004 a new series of guidelines for foreign language instruction throughout Switzerland (9). One of the innovations was the early introduction of a second foreign language in primary schools (either French or English), which raised the question asked by both parents and members of CI teams whether CI patients could and should also participate in this program or not. Congenitally, deaf patients with CI already make considerable efforts to acquire one language, so it is legitimate to ask whether most of them are able to acquire another one. It is known that a significant number of CI patients raised in a bilingual environment are capable of learning both mother tongues (10–12). In these studies, CI children were (more or less) constantly exposed to the second language at home. Learning a foreign language at school also involves another dimension since children are exposed to the new language for only 2 to 4 hours per week. To our knowledge, the issue of the acquisition of foreign languages at school in cochlear implant patients has not yet received attention. This pilot study, therefore,

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sought to answer two main questions. Do CI children and adolescents receive foreign language education at school? How do they perform and are they able to attain the performance levels defined by the current school system?

METHODS

Subjects

Within our CI database, we identified 60 patients currently aged 10 to 25 years. Owing to incomplete data sets, previous CI explantation or CI-nonusers, mental retardation, or concomitant medical disorders, we were able to include 43 patients for further evaluation (Fig. 1). Basic patient characteristics and audiometry data were extracted from the database. Patients and parents were contacted with a questionnaire and information was obtained regarding type of schooling, foreign language learning, and bilingualism. All CI users with tuition in at least one foreign language at school were encouraged to participate for further subjective and objective testing.

Language Tests

Language tasks from Lingualevel were used (13). Lingualevel is based on the Common European Framework of Reference for Languages (CEFR). The CEFR distinguishes between receptive skills (listening and reading) and productive skills (speaking and writing). A language user can develop various degrees of competence in each of these domains. For the comparison of skills, the CEFR provides a set of six common reference levels: A1 (beginner), A2 (elementary), B1 (intermediate), B2 (upper intermediate), C1 (advanced), C2 (proficiency). Each level is divided into two sublevels (e.g., A 1.1 and A 1.2) (Fig. 2).

Several descriptors (Can-Do statements) are used to evaluate the competences of a person in each language activity. For example, ''I can introduce myself to others'' corresponds to level A 1.1. For the purpose of this study, we mainly used receptive skills (reading and listening) since they are not dependent on the subjective evaluation of the investigator.

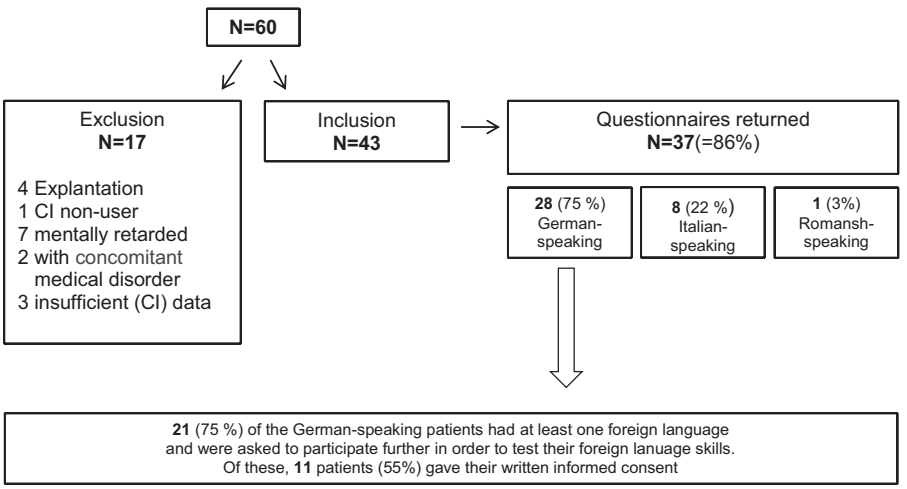
We performed two different language tests: a subjective test, where CI users were asked to rate their personal skills. For this purpose, a self-assessment questionnaire was designed that included a selection of the Lingualevel descriptors, each corresponding to a certain level. Secondly, an objective language test was performed where the subject was asked to complete several tasks selected from Lingualevel (Fig. 1). The volume of each foreign language listening test was not fixed and the most comfortable level (65–85 dB) was sought for each subject. Each test was explained by the investigator and subjects were allowed to ask questions. To verify the capability of German-reading skills, a standardized German reading test (14) was used. To rate production skills in English, the subjects were asked to introduce themselves in English and their presentation was recorded on video. Speech production was evaluated by an independent judge with a good knowledge of the English language.

Basic speech capability in one's mother tongue was tested using the validated international outcome inventory for hearing aids (IOI-HA) (15), speech intelligibility rate (SIR) (16), and capacity of auditory performance (CAP) (17) questionnaires.

All test results were compared with the Swiss foreign language norm ''Lehrplan 21'' (2015) for English and French regarding reading and listening skills.

Statistics

Data were collected in an MS Excel Database (MS Excel 2010). Encoded and anonymized data were collected in an SPSS



Tests n=11	Receptive tests				Production tests	
	Reading skills		Listening skills		Speech production	
	Lingualevel	Self-assessment	Lingualevel	Self-assessment	Lingualevel	Self-assessment
German (n=11)	1 task (15 minutes)	✓		✓		✓
English (n=11)	2 tasks (25 minutes)	✓	3 tasks (12 minutes)	✓	1 task (5 minutes)	✓
French (n=6)	2 tasks (20 minutes)	✓	2 tasks (10 minutes)	✓		✓

FIG. 1. Flow chart of recruited CI patients. All German-speaking patients with at least one foreign language underwent further testing of their foreign language skills. CI indicates cochlear implants.

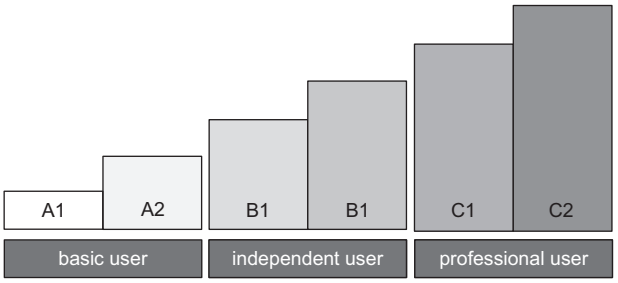


FIG. 2. Common European framework of reference for languages (CEFR).

Database (IBM SPSS Statistics 21). For both the primary and secondary outcomes, the statistical analysis was mostly descriptive, but where possible, we used the Pearson χ^2 and the unpaired t test to evaluate statistical significance. For correlations between the objective and subjective measurements, the Pearson Correlation test was used. P values of <0.05 were considered as statistically significant.

Ethical Approval

The study protocol was approved by the Ethical Committee of Central Switzerland (EKNZ) Nr.2015-383.

RESULTS

Questionnaires

Forty-three patients and families were contacted and 37 initial questionnaires (86%) were returned. The majority of the patients (n = 28) live in the German-speaking part of Switzerland, whereas eight live in Tessin (the Italian-speaking part), and one in Rhaeto-Romanic (Fig. 1). The results of the questionnaires are shown in Table 1 in which Italian- and Rhaeto-Romanic-speaking patients were grouped together owing to their small numbers. Results of mainstream and special schooling for hearing-disabled are shown separately. Among the 28 German-speaking CI users, 12 pupils (43%) were able to finish mainstream schooling (both primary and secondary school). Also for the nine Italian/Rhaeto Romanic-speaking CI users, four pupils (44%) were able to finish mainstream schooling. All mainstream pupils from the German-speaking group attended foreign language lessons at school compared with 9/16 (56%) pupils with special schooling. In all cases, the first or only foreign language was English. Of the Italian/Rhaeto-Romanic-speaking CI users, 3/4 (75%) pupils from mainstream schooling and 3/5 (60%) from special schooling attended foreign language lessons. The first or only foreign language was English, French, or German. Overall, 27/37 (=73%) CI users are learning or have learnt at least one foreign language at school, and 17/37 (=46%) have even studied two foreign languages. From the 10 CI users without foreign language learning, all but one had special schooling for hearing-disabled (9/10 = 90%). Contrariwise, all but one CI users out of mainstream schooling had foreign language education (15/16 = 94%). Within the group of 21 CI users in special schooling for the hearing-disabled, 12 pupils (12/21 = 57%) attended foreign language classes.

Among the foreign language learners, 12 CI users have bilateral CI (12/27 = 44%). Five out of 10 pupils (5/10 = 50%) without foreign language education underwent bilateral CI implantation.

Table 2 shows the most important audiological CI-patient characteristics with and without foreign language learning at school.

Aided hearing levels were equal (range, 26.7–28.1 dB HL), but speech comprehensibility varied significantly ($p < 0.05$): CI users with foreign language learning at school had monosyllable scores from 73.1% (right) to 74.8% (left), compared with CI users without foreign language acquisition who scored from 29.5% (right) to 45.7% (left); ($p = 0.002$ and $p = 0.025$, respectively). In view of these results, we also compared monosyllable scores between all CI users in mainstream schooling (81.0% right and 72.9% left) and all CI users in special schooling for the hearing-disabled (43.4% right and 63.8% left). This showed a significant difference for the right ear ($p = 0.001$). We assumed the result was the same for the left ear although we could not calculate the score in 25% of the CI users since no data concerning the non-implanted left ears were available. CI users in mainstream schooling also had better CAP (max 7) and SIR (max 5) scores (6.6 and 4.6) compared with CI users in special schools

TABLE 1. *Results of questionnaires*

	German-Speaking n = 28		Italian/Rhaetoromanic-Speaking n = 9		
Results Questionnaires (10–25 yr)	Mainstream n = 12 (43%)	Special Schooling n = 16 (57%)	Mainstream n = 4 (44%)	Special Schooling n = 5 (56%)	Total n = 37
Mean age at first CI in years (range)	7.0 (0–17)	7.4 (1–17)	3.0 (1–6)	6.2 (3–12)	6.6 (0–17)
Patients with bilateral cochlear implant	4	6	3	4	14 (38%)
Patients with bilingualism at home	4	5	2	0	11 (30%)
At least one foreign language	12 (100%)	9 (56%)	3 (75%)	3 (60%)	27 (73%)
At least two foreign languages	8	6	1	2	17 (59%)
English	12	9	1	1	23 (62%)
French	8	6	1	1	16 (43%)

CI indicates cochlear implants.

TABLE 2. *Results of questionnaires, CI users with at least one foreign language and without any foreign language are grouped together*

n = 37	At least One Foreign Language (n = 27)	No Foreign Language (n = 11)	*p*
Age of first CI	6.9 yr (range, 0–4)	6.0 yr (range, 1–15)	0.597
CI hearing age	10.5 yr (range, 0–21)	11.4 yr (range, 4–19)	0.651
PTA (0.5–4 kHz) right ear	27.3 dB HL (range, 18–38.8)	28.1 dB HL (range, 18.8–41.3)	0.755
PTA (0.5–4 kHz) left ear	27.0 dB HL (range, 15–56.3)	26.7 dB HL (range, 15.1–56.3)	0.954
Monosyllable scores (right ear)[a]	73.1% (range, 0–80)	29.5% (range, 0–80)	**0.002**[b]
Monosyllable scores (left ear)[a]	74.8% (range, 15–100)	45.7% (range, 10–70)	**0.025**[b]
Monosyllable scores (both ears)[a]	89.1% (range, 60–100)	62.5% (range, 20–100)	0.100

[a]At signal level 65.
[b]Statistical significance $p < 0.05$ (unpaired *t* test).
CI indicates cochlear implants; PTA, pure tone audiometry.

(5.6 and 3.6); $p = 0.09$ and 0.043, respectively. This means that CI users in mainstream schooling had significantly better auditory performances (CAP) and also showed a trend towards better speech intelligibility (SIR). Other variables such as multilingualism at home, unilateral, or bilateral CI, and age at first implantation did not show any difference.

Language Tests

Of the German-speaking CI users with foreign language learning, 11 (55%) accepted further testing. Nine were women (9/11 = 82%) and the median age was 15 years (range, 11–25 yr). Seven pupils (7/11 = 64%) were bilaterally implanted while the others were using conventional hearing aids on their overall worse contralateral ear. All of the pupils use the CI greater than 8 hours per day. The average IOI-HA score was 27.2 (range, 17–34; maximal score 34) indicating that most CI users are satisfied with their CI. The average SIR and CAP scores were 5/5 and 6.8/7, meaning that all CI users are easily comprehensible in their mother tongue.

Five patients (45%) were raised bilingual at home (languages Spanish, Portuguese [2x], Albanese, and Italian). Six CI users (55%) had mainstream schooling and five CI users (45%) had special schooling for the hearing-disabled. The median monosyllable speech comprehension score at 65 dB for the better hearing ear was 95% (range, 75–100%).

The test results are shown in Figure 3 for both English (n = 11) and French (n = 6). Concerning reading skills, 7/11 (64%, English) and 3/6 (50%, French) CI users had attained the ''Lehrplan 21'' objectives. Of these, 57 and 50%, respectively were in mainstream education.

For listening skills, only three (27%) of the tested pupils (all of them in mainstream schooling) achieved normative values in English and none achieved the norm in French.

Speech production corresponded on average to level A2.1 (range, A1.1–A2.2), with 7/11 (64%) reaching the ''Lehrplan 21'' objectives. Of these, only four had also reached the school objectives for reading and two for listening skills. Concerning the German reading test, the mean percentage of correct answers was 40% (range, 0–80%) without any correlation with foreign language skills. There were no significant correlations between monosyllable scores, multilingualism at home, unilateral or bilateral CI, and age at implantation.

There was a positive correlation between the self-assessment test results and the objective test scores. Overall, CI users judged themselves to be at a higher language level than measured by the test.

Discussion and Conclusions

The four national languages in Switzerland are German, French, Italian, and Romansh. The German-speaking region occupies the east, north, and center and comprises about 65% of the country. Their mother tongue consists of Swiss German (spoken language with many dialects, no specific grammar). Standard German is taught at kindergarten and primary school. Standard German, often also referred to as High German, is therefore the first ''foreign''

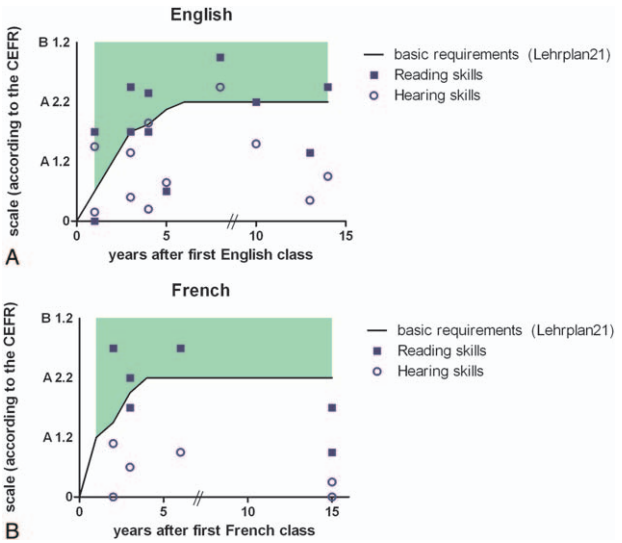


FIG. 3. Test results English reading/listening skills (*A*) and French reading/listening skills (*B*) according to the common framework of reference for languages (CEFR) are plotted against the years of language tuition. The school norm (*"Lehrplan21"*) (line) is shown.

language with its explicit grammar. English is often taught officially as the first foreign language at primary schools and a current debate throughout the country focuses on the importance of English versus French as the first foreign language. Hearing-impaired children struggle to acquire both Swiss and High German during their speech rehabilitation and are uniformly tested in their High German skills. Whereas the benefits of CI have been documented in a large number of publications, all of them in the official language of the reporting country, we were interested in the rather unique situation of Switzerland with its four official languages and the teaching of English as an additional foreign language early in primary schools.

The results of this study show that 27 of our 37 CI children (73%) are able to acquire at least one foreign language at school either in a mainstream or special school setting. Among the tested CI users, (7/11) 64% and (3/6) 50% reached the ''Lehrplan 21'' school objectives in English and French reading skills. With regard to listening skills, the results were much different, showing that only one-third of the pupils reached the norm in English listening skills and none of them in French.

The percentage of CI users entering mainstream education in our study (16/37 = 43%) is in line with the results of previous studies ranging from 36 to 83%, with higher percentages found in the younger age groups (5–8,18,19). In German mainstream education, 94% of the CI users have learned at least one foreign language, whereas about half of the CI users in special schools for the hearing-disabled went to foreign language classes. In turn, if we consider all 10 CI users who never had foreign language tuition at school, all but one had special schooling for the hearing-disabled. Generally, CI users going to special schools have worse speech comprehensibility (43.4% right and 63.8% left) compared with those in mainstream education (81.0% right and 72.9% left), with a significant difference at least for the right ear. We assume that this difference is also true for the left ear, since five CI users (25%) with monosyllable scores less than 50% in the right (CI-implanted) ear had not been tested recently on their non-implanted left ear. By considering the non-implanted ear as the worse hearing ear, we assume that CI users in special schools for the hearing-disabled have worse hearing, worse language scores, and generally worse school performance. This is in line with the results of Langereis and Vermeulen (19). Their study performed in the Netherlands reported that all CI users in a mainstream school setting showed similar school results to the national school norm sample (25% scored below average), whereas 65% of the CI users in hard-of-hearing education and 85% of the CI users in deaf education scored below average. They also found significantly lower speech perception in CI users in special schools compared with those in mainstream education. They concluded that a normal hearing environment, i.e., mainstream education, has a positive effect on school results. This may be true for children with an overall good CI performance. In view of our experience, we suggest that the ability to participate in a mainstream school environment could also be a prognostic factor for achieving satisfactory school results because of better auditory performances of the CI users in mainstream (in particular the ability to benefit from foreign language tuition). Noticeably, overall performance may also depend on the educational level of the parents, social-economic status, ethnicity, and age at implantation (18). In our study, we did not find any such correlations, although our study population was too small for such a multifactorial analysis.

Although CI users in mainstream education were more likely to receive foreign language tuition, they did not perform better (according to the objective [Lingualevel] test results from our study) than CI users in special schools. Overall, we found that 50 and 64% of the CI users tested were able to reach the school norm in reading skills in English and French, respectively. A research project in Lucerne undertaken in 2009 and involving 893 normal hearing children showed that 77% of primary scholars reached the school norm in 6th grade in reading skills in English (14). For French listening skills, 92% reached or surpassed the norm. The investigators also reported that among the children not reaching the target levels, most were ''special-needs children with reduced learning objectives,'' children from families with a migration background and lower educational background and children who reported being overtaxed in the foreign language lessons (14). As there are no other publications on foreign language performance for CI pupils, we are unable to compare our results with others.

Our small group of participating subjects did not allow us to explore significant differences between CI users who reached the school norm and those who did not. Since these differences are of great interest, we searched for individual factors and trends. The lack of any correlation between the High German test results and the foreign language test battery was mainly due to too difficult tasks in our German test. The audiological tests and number of books at home (indicator for the education level) were similar in both groups. We found no correlations between the school notes and our test results. It has to be noted that almost half of the CI pupils were dispensed for school notes for foreign languages. A potential selection bias could be that CI users with better foreign language performance at school were more willingly to participate in our study. However, we found no difference between the school notes or exemption from school notes between participants of this study and pupils returning the questionnaire and declining their further participation.

An interesting but not surprising finding was that CI users performed worse in listening than in reading skills: none of the six pupils reached the norm for French listening skills and only (3/11) 27% could reach the norm in English. In contrast, normal-hearing children were reported to perform much better in listening than in reading (92 and 64%, respectively) tasks (14).

One of the reasons for such under rated listening scores may be that CI users continue to benefit from

their lip-reading skills. Our tests were based on audio sound on CD from professional speakers. We plan to investigate in a further study the difference between foreign language audio recordings to video testing with lip-reading features.

Most CI users do get further training by specialized speech therapists also in mainstream schools, but this help is given in High German. We are not aware that schools employ speech therapists with foreign language certifications. Interestingly, most of our CI pupils were not using an frequency modulation (FM) system during foreign language classes, even if it is available. We learned from foreign language teachers that the use of FM-systems in classrooms with many group discussions and conversations among students does not allow proper usage of FM-systems, since the receiver needs to be handed over too many times.

The present investigation is a pilot study. We have started a multicentre study involving other CI-centers and their CI users in the German-speaking parts of Switzerland and thereafter in the French- and Italian-speaking regions. We have learned that tests should not exceed a total time of 2 hours, that our previously used High German language test should be revised, and that CI users and parents do need motivation to participate. Although we did not have any indication for selection bias in the present study, the selection bias of ''CI users with better foreign language performance at school may be more willingly to participate'' should be kept in mind. A further development would be to set up a study with a matched control group by collaborating with the University for Teacher Education in Lucerne.

CONCLUSIONS

Almost 75% of the CI children and adolescents at our CI center are able to acquire at least one foreign language at school. In German speaking mainstream schools, all CI pupils are enrolled in foreign language learning programs. Even in special school environments, over half of all CI scholars are being trained in a foreign language. Out of 11 children trained in English, seven were able to reach the school norm in English reading skills while three out of six children trained in French reached the reading norm. An interesting but not surprising finding was that CI users performed much worse in listening than in reading skills, which is in contrast to normal-hearing children, who seem to perform better in listening tasks. These results indicate that CI users may need special support in at least listening skills when learning foreign languages.

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